C. REMARKS

1. Status of the Claims

Claims 1-4, and 21-22 are currently pending. Claim 1 is independent. Claims 2-4, and 21-22 depend on claim 1. New Claims 23-33 are being presented in the current response.

In the Office Action dated December 16, 2002, the Examiner has rejected claims 1-4 and 21-22 under 35 U.S.C. §103.

In response, Applicant hereby amends claims 1, 3-4, and 21. In addition, Applicant cancels claim 2, and adds new claims 23-33.

As a result, claims 1, 3-4, and 21-33 are being presented for consideration. Of these claims, claims 1, 27, and 33 are independent. Claims 3-4, and 21-26 depend on claim 1. Claims 28-32 depend on claim 27.

Applicant submits that in view of the above amendments, cancellations, and additions (all of which are fully discussed below), as well as the arguments set forth below, claims 1, 3-4, and 21-33 are now in condition for allowance.

2. Rejection of Claims 1, 2, 4, and 21-22 under 35 U.S.C. § 103(a)

Claims 1, 2, 4, 21, and 22 have been rejected under 35 U.S.C. 103(a) as being unpatentable over EPO 0 624 900 A2 ("Sparks") in view of US 5,578,976 ("Yao"). Applicant respectfully traverses these rejections, in view of the amendments discussed below.

Claim 1

Regarding claim 1, the Examiner states:

"Regarding claim 1, Sparks, a reference provided by Applicant in IDS filed 16 September 2002 discloses a method of fabricating a microstructure in a sealed cavity comprising,

providing a substrate 10 (Fig. 9a);

forming a microstructure 18 composed of a structural material 18 on said substrate, said microstructure being secured to said substrate by a first layer of sacrificial material 48 (Fig. 9a);

forming a second layer of sacrificial material 48 on said microstructure (Fig. 9a),

forming a cap 50 on said second layer of sacrificial material 48, said cap forming a sealed cavity containing said microstructure and said first and second sacrificial layers (Fig. 9b);

forming one or more holes 52 in said sealed cavity, said holes being restricted to an area of saic sealed cavity not directly above said microstructure (Fig. 9c);

introducing an oxygen plasma into said sealed cavity through said one or more holes 52, said structural material and said sacrificial material having a high etch rate differential with respect to said etchant, such that said sacrificial material is removed (col. 10, lines 46-50); and sealing said one or more holes in said sealed cavity (Fig. 9d).

(See associated text at col. 15, line 25 to col. 16, line 23.)"

The Examiner further states:

"Sparks does not indicate that the cap 50 is formed of metal.

Yao teaches a method of forming a MEMS comprising providing a substrate 12, sacrificial layers of photoresist 30, 38 (called "polyimide" in Yao; Figs 5A-6E) which secure the MEMS to the substrate until etched away, and structural material of aluminum 22, 24. Yao also discloses that it is especially beneficial to use a barrel etcher with an oxygen plasma to remove the sacrificial layers in order to circumvent problems associated with surface tension created by wet etching. (See Yao, col. 5, lines 41-65 and especially col. 6, lines 6-13.)

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use the materials of Yao in the method of Sparks and thereby form the cap in Sparks of aluminum, because (1) Sparks is not limited to the materials from which the device is made, (2) both Sparks and Yao are making a cantilever microstructures, and Yao teaches that aluminum is also compatible with oxygen plasma during etching of sacrificial layers, and (4) the selection of a known material based on its suitability for its intended use is *prima facie* obvious. The selection of a known material based on its suitability for its intended use supported a *prima facie* obviousness determination in *Sinclair & Carroll Co., Inc. v. Interchemical Corp.* , 325 U.S. 327, 65 USPQ 297 1945) (Claims to a printing ink comprising a solvent having the vapor pressure characteristics of butyl carbitol so that the ink would not dry at room temperature but would dry quickly upon heating were held invalid over a reference teaching a printing ink made with a different solvent that was nonvolatile at room temperature but highly volatile when heated in view of an article which taught the desired boiling point and vapor pressure characteristics of a solvent for printing inks and a catalog teaching the boiling point and vapor pressure characteristics of butyl carbitol. "Reading a list and selecting a known compound to meet known requirements is no more ingenious than selecting the last piece to put in the last opening in a jig saw puzzle." 65 USPQ at 3 0 1.). See also *In re LESHIN*, 125 USPQ 416 (CCPA 1960). (See also MPEP 2144.07.)"

Applicant respectfully traverses the Examiner's rejections.

As a preliminary matter, Applicant notes that Fig. 9a in Sparks does not disclose forming a second layer of sacrificial material 48 on the microstructure, contrary to the Examiner's statements. In Sparks, only a single layer of sacrificial material (indicated in Sparks by reference numeral 48) is deposited, and nowhere in Sparks is it taught, disclosed, or suggested that a second layer of sacrificial material be deposited on a substrate. See Sparks Col. 15, lines 25-27 ("Illustrated in Figures 9a to 9d is a polyimide encapsulation process which employs a sacrificial polyimide layer . . . ")(boldface added).

In addition, Applicant has extensively amended claim 1, in response to the above rejections by the Examiner. Specifically, claim 1 has been amended to add the following limitations (newly added phrases are within quotation marks):

1) a substrate "having a substantially planar support surface"

2) "depositing a first layer of sacrificial material over said planar support surface"

3) "depositing an etchable layer of structural material over said first layer of sacrificial material";

4) forming a microstructure "on said support surface by etching said layer of structural material," said microstructure "contacting said substrate at least at an anchor point";

5) "said dry plasma etchant removes said first and second sacrificial layers while leaving said microstructure and said substrate substantially intact, thereby releasing said microstructure as a movable structure secured at said anchor point to said substrate"; and

6) "thereby forming a sealed cavity that encapsulates said movable microstructure, said sealed cavity being defined by said seal layer and said planar support surface."

Support in the specification for limitation 1) above can be found, for example, on page 4, line 28, and FIG.s 1B, 2B, 3B, 4B, 5B, 6B, 7B, 8B, and 9B. Support in the specification for limitation 2) above can be found, for example, on page 5, lines 2-3. Support in the specification for limitations 3) and 4) above can be found, for example, on page 5, lines 18-21. Support in the specification for limitation 5) above can be found, for example, on page 7, lines 4-7, and 13-15. Support in the specification for limitation 6) above can be found, for example, on page 4, lines

19-21 and lines 23-25, page 7, lines 20-26, and FIG. 9B.

Sparks is directed to bulk surface micromachining processes, in which microstructures are formed by etching the surface of the substrate itself, in contrast to the present invention, which teaches the etching of a structural layer deposited on top of a substrate, to form a microstructure. Sparks explicitly distinguishes these different processes, thus teaching away from the present invention: "Bulk micro-machining of silicon wafers is well known . . . Generally, this process involves forming semiconductor devices on a silicon wafer by etching the bulk silicon at the surface of the wafer, **in contrast to** etching methods in which semiconductor devices are formed by selectively etching layers which were previously deposited on the surface of the wafer substrate. (underlining and boldface added) (Sparks Col. 1, lines 12-19).

In particular, Sparks discloses implanting donor ions on the silicon substrate to create of N+ region. An epitaxial layer is then grown from the substrate over the N+ region, thereby "burying" the N+ region to create a buried N+ layer. The epitaxial layer is masked and etched to form trenches through the epitaxial layer and into the buried N+ layer. The N+ buried layer is laterally etched away, leaving in its place a void region. In this way, a cavity is formed below the surface of the substrate. The remaining portion of the epitaxial layer (above the cavity formed by etching away the N+ buried layer) forms a micro-machined element. In Sparks, therefore, the micro-machined element is formed from the material of the substrate itself, rather than from structural material that is deposited onto the substrate and etched into a desired pattern, as in the present invention.

Yao does not teach, suggest, or relate in any way to any encapsulation process. In particular, Yao does not teach introducing a dry plasma etchant through ports formed through a seal layer that forms part of a sealed cavity (or closed capsule), so as to remove sacrificial material within the sealed cavity, leaving a movable microstructure within the cavity. The sacrificial materials in Yao are treated at high temperatures, and not enclosed within a cavity, unlike the present invention.

In contrast to both Spark and Yao, the present invention teaches the gas phase release of encapsulated microstructure layers. In particular, the present invention teaches the introduction

of dry plasma etchant into the interior region of a capsule through holes in a cap layer that forms part of the capsule. This causes the removal of sacrificial layers within the capsule, so that the microstructural layer disposed in between the sacrificial layers is released as a movable microstructure within the capsule. Another seal layer is applied in order to plug the holes and seal the cavity containing the movable structure. In this way, microstructures are fabricated that are movable within a sealed cavity, without suffering from the numerous disadvantages of wet-etching processes, which were the only techniques known in the art (before the invention disclosed in the present application) for fabricating such movable encapsulated microstructures.

Although plasma dry etching techniques are well known in the art for semiconductor fabrication, and in particular for bulk surface micromachining processes, it was not known before the invention of the present application to introduce dry plasma etchants into the interior of a capsule in order to release microstructures formed from structural layers deposited between two sacrificial layers, so as to fabricate an encapsulated movable (or suspended) microstructure. This point has been explained several times in previous responses, for example in Applicant's Response dated September 18, 2002, in which Applicant quoted Dr. Carley as being "unaware of anyone using plasma as an etchant for releasing encapsulated MEMS devices, principally because of the extremely long etch period required when using small aspect ratio vias to introduce the etchant and to etch large areas under the cap."

Applicant submits that claim 1, as amended, is patentable over Sparks and Yao, at least because Sparks and Yao (either alone or in combination) does not teach or suggest at least the following limitations of amended claim 1:

1) "depositing a cap layer over said second layer of sacrificial material, whereby said cap layer and said planar support surface define a capsule about an interior region containing said microstructure and said first and second sacrificial layers";

2) "introducing a dry plasma etchant into said interior region through said one or more holes,

wherein said sacrificial material is chosen to have a high etch rate differential with respect to said structural material, so that said dry plasma etchant removes said first and second sacrificial layers

while leaving said microstructure and said substrate substantially intact, thereby releasing said microstructure as a movable structure secured at said anchor point to said substrate"; and

3) "sealing said one or more holes in said cap layer with a seal layer, thereby forming a sealed cavity that encapsulates said movable microstructure, said sealed cavity being defined by said seal layer and said planar support surface."

Regarding limitation 1) above, Yao does not teach, suggest or mention any encapsulation process whatsoever, as explained before. As for Sparks, Sparks does not teach or suggest "depositing a cap layer over a second layer of sacrificial material," as noted above. Rather, the cap layer in FIG. 9a of Sparks is deposited over a single layer of sacrificial material. In Sparks, the microstructure is not formed between first and second sacrificial layers, as in the present invention, but rather is formed by what remains of the surface of the substrate, after the N+ doped region (buried within the surface of the substrate) has been etched away. Also, Sparks does not teach or suggest that "said cap layer and said planar support surface defined a capsule about an interior region containing said microstructure and said first and second sacrificial layers." In Sparks, the cavity is formed by etching away part of the surface of the substrate, and the cavity extends laterally below the surface of the substrate. Therefore, in Sparks no planar support surface of a substrate defines (together with a cap layer) a capsule about an interior region containing the microstructure and first and second sacrificial layers.

Regarding limitation 2) above, Yao (which does not relate in any way to encapsulation) does not teach or suggest introducing a dry plasma etchant into the interior region of a capsule. In particular, Yao does not teach or suggest introducing the dry plasma etchant through one or more holes in a cap layer that defines (together with a planar support surface of a substrate) a capsule about an interior region that contains a microstructure disposed between two sacrificial layers.

As for Sparks, Sparks does not teach or suggest introducing a dry plasma etchant into an interior region of a capsule defined by a planar support surface of a substrate and a cap layer. In contrast to the present invention, the dry plasma etchant in Sparks is introduced into a cavity formed by etching away part of the substrate itself. Therefore, the interior region of the cavity in

Sparks is not defined by a planar support surface of a substrate.

Further, Sparks does not teach or suggest removing of first and second sacrificial layers within the interior region using the dry plasma etchant, so as to release the microstructure as a movable structure that is secured at an anchor point to the substrate. Rather, the dry plasma etchant in Sparks is used to etch away a single layer of sacrificial material. Also, in Sparks it is not the etching of sacrificial material that releases the microstructure as a movable structure, since the microstructure is already formed so as to be suspended over a cavity, before the introduction of sacrificial material into the cavity. Also, the microstructure in Sparks is not secured at an anchor point to the substrate, but rather consists of the remaining part of the surface of the substrate, after a buried layer has been etched away.

Regarding limitation 3) above, Yao does not relate in any way to encapsulation. Further, Sparks does not teach or suggest the formation of a sealed cavity that is defined by a planar support surface of a substrate and a seal layer. In Sparks, the cavity is defined within the substrate (by the etching away of a region buried within the substrate), rather than being defined by a planar support surface of the substrate and a seal layer. Also, in Sparks the cavity is formed before the etching away of sacrificial material by the dry plasma etchant, unlike the present invention, in which the cavity is formed by depositing a seal layer after the sacrificial layers have been removed by the dry plasma etchant.

Applicant also notes that Sparks does not teach the following limitations of amended claim 1:

a) "depositing an etchable layer of structural material over said first layer of sacrificial material"; and

b) "forming a microstructure on said support surface by etching said layer of structural material, said microstructure contacting said substrate at least at an anchor point";

As explained above, Sparks teaches the etching away of part of the surface of the substrate, and forming a microstructure from the remaining portion of the substrate surface. Sparks therefore teaches away from limitations a) and b), i.e. depositing an etchable layer of structural material over the first layer of sacrificial material, and forming a microstructure by etching the layer of

structural material.

Because Sparks and Yao, either alone or in combination, does not teach or suggest the limitations 1), 2), and 3) discussed above, and because Sparks teaches away from the present invention, in particular from limitations a) and b) of amended Claim 1, Applicant submits that Claim 1, as currently amended, is not obvious over Sparks in view of Yao.

Claim 2

Claim 2 has been cancelled.

Claims 4, and 21-22

Regarding claim 4, the Examiner states:

"Regarding claim 4, polyimide is a known photoresist material, so photoresist is implicitly disclosed in each of Sparks and Yao. "[I]n considering the disclosure of a reference, it is proper to take into account not only specific teachings of the reference but also the inferences which one skilled in the art would reasonably be expected to draw therefrom." See *In re Preda*, 401 F.2d 825, 826, 159 USPQ 342, 344 (CCPA 1968). See also *In re Lamberti*, 545 F.2d 747, 750, 192 USPQ 278, 280 (CCPA 1976)."

Regarding claims 21-22, the Examiner states:

"Regarding claims 2, 21, and 22 it is seen to be inherent in each of **Sparks** and **Yao** that the etchant does not significantly etch the structural materials therein because the structures are shown to remain after the sacrificial material is etched away. Similarly, the etchant etches the sacrificial material faster and the structural material slower and the structural material is shown to be resistant to the etchant. Moreover, if these limitations were not met by **Sparks** and **Yao**, then no microstructure could effectively be formed in either invention, in direct contrast to what is shown in each."

Applicant submits that, in view of the amendments to Claim 1 discussed above, these rejections are overcome, and that Claims 4, and 21-22, which depend from claim 1, are patentable at least for the same reasons (discussed in detail above) claim 1 is patentable.

3. **Rejection of Claim 3 under 35 U.S.C. § 103(a)**

Claim 3 has been rejected under 35 U.S.C. 103(a) as being unpatentable over **Sparks** in view of Yao, as applied to claim I above, and further in view of US 5,493,177 (Muller et al.). In particular, the Examiner states:

"While each Sparks and Yao disclose that the substrate is silicon, the protective silicon nitride layer formed on the silicon substrate does not appear to be disclosed therein.

Muller, a reference provided by Applicant and discussed in the instant specification at page 2, discloses a method of fabricating a microstructure in a sealed cavity. As noted by Applicant in the specification on page 2, regarding the Muller reference, the substrate is silicon with a protective silicon nitride layer 178 is formed thereon.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to apply a protect layer of silicon nitride to the silicon substrate of Sparks because Muller teaches that it provides protection to the silicon substrate during etching of a cavity, such etching of a cavity as has also been carried out in Sparks."

Applicant submits that, in view of the amendments to Claim 1 discussed above, these rejections are overcome, and that claim 3, which depends from claim 1, is patentable at least for the same reasons (discussed in detail above) claim 1 is patentable.

4. **New Claims 23-33**

Applicant submits that new claims 23-26, which depend from amended claim 1, are patentable at least for the same reasons claim 1 is patentable.

New independent claim 27 is directed to an intermediate micromachined structure. Claim 27 is patentable over Sparks and Yao, at least because Sparks and Yao (either alone or in combination) do not teach at least the following limitations of claim 27, for the reasons discussed above in connection with amended claim 1:

"a cap layer extending from points on said planar support surface and deposited over said second sacrificial layer, said cap layer and said support surface defining a capsule about an interior region containing said microstructure and said first and second sacrificial layers;" and

" wherein the materials forming said sacrificial layers and said structural layer are chosen so as to

allow a dry plasma etchant, when introduced into said interior region through said one or more ports, to etch away said first and second sacrificial layers while leaving said microstructure substantially intact, thereby forming a cavity defined by said cap layer and said planar support surface, and releasing said microstructure as a movable suspended structure contained within said cavity."

Also, claim 27 is patentable over Sparks because Sparks does not teach or suggest "a microstructure disposed at least in part above said plane," the plane being the plane that characterizes the planar support surface of the substrate.

New claims 28-32 depend on claim 27, and are patentable at least for the same reasons claim 27 is patentable.

New independent claim 33 is directed to a micromachined assembly. Claim 33 is patentable over Sparks and Yao, at least because Sparks and Yao (either alone or in combination) do not teach at least the following limitations of claim 33, for the reasons discussed above in connection with amended claim 1 and new claim 27:

"a microstructure disposed at least in part above said plane and having at least one end secured to said substrate at an anchor point"; and

"a cap layer extending from points on said planar support surface, said cap layer and said support surface defining a capsule about an interior region containing said microstructure."

5. Conclusion

On the basis of the foregoing amendments, Applicant respectfully submits that all of the pending claims 1, 3-4, and 21-33 are in condition for allowance. An early and favorable action is therefore earnestly solicited. If there are any questions regarding these amendments and remarks, the Examiner is encouraged to contact the undersigned at the telephone number provided below.

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